Mechanics: Work, Energy and Power Worksheet Name: KEY

Work Questions:

1. A tugboat pulls a ship with a constant net horizontal force of 5.00×10^3 N and causes the ship to move through a harbor. How much work is done on the ship if it moves a distance of 3.00 km?

$F = 5000N$, $d = 3000m$, $\theta = 0°$

$W = Fd\cos\theta$

$= (5000N)(3000m)\cos(0) = \boxed{1.5 \times 10^7 J}$

2. A shopper in a supermarket pushes a cart with a force of 35 N directed at an angle of 25° downward from the horizontal. Find the work done by the shopper on the cart as the shopper moves along a 50.0 m length of aisle.

$F = 35N$, $d = 50m$, $\theta = 25°$

$W = Fd\cos\theta$

$= (35N)(50m)\cos(25°) = \boxed{1586 J}$

3. If 2.0 J of work is done in raising a 180 g apple, how far is it lifted?

$W = 2J$, $m = 0.180$, $d = x$, $\theta = 0$

$F = mg$

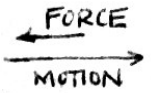
$= (0.180g)(10m/s^2)$

$= 1.8N$

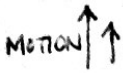
$W = Fd\cos\theta$

$d = \frac{W}{F\cos\theta} = \frac{2J}{1.8N \cdot \cos(0)} = \boxed{1.11m}$

4. For each of the following cases, indicate whether the work done on the second object in each example will have a positive or negative value.

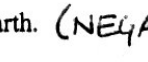


a. The road exerts a friction force on a speeding car skidding to a stop. (NEGATIVE)



b. A rope exerts a force on a bucket as the bucket is raised up a well. (POSITIVE)

c. Air exerts a force on a parachute as the parachutist falls to Earth. (NEGATIVE)



Kinetic Energy Questions:

5. What is the speed of a 0.145 kg baseball if its kinetic energy is 109 J?

$KE = 109J$, $m = 0.145kg$, $v = x$

$KE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2KE}{m}} = \sqrt{\frac{2(109J)}{0.145kg}} = \boxed{38.8 m/s}$

6. Two 3.0 g bullets are fired with speeds of 40.0 m/s and 80.0 m/s respectively. What are their kinetic energies? Which bullet has more kinetic energy? What is the ratio of their kinetic energies?

$m_1 = 0.003kg$, $v_1 = 40.0m/s$, $KE_1 = x_1$

$m_2 = 0.003kg$, $v_2 = 80.0m/s$, $KE_2 = x_2$

$KE = \frac{1}{2}mv^2$

$KE_1 = \frac{1}{2}(0.003kg)(40m/s)^2 = \boxed{2.4J}$

$KE_2 = \frac{1}{2}(0.003kg)(80m/s)^2 = \boxed{9.6J}$

1:4 RATIO

7. A car has a kinetic energy of 4.32×10^5 J when traveling at a speed of 23 m/s. What is its mass?

$m = x$, $KE = 432000J$, $v = 23m/s$

$KE = \frac{1}{2}mv^2$

$m = \frac{2KE}{v^2} = \frac{2(432000J)}{(23m/s)^2} = \boxed{1633.3kg}$

Work-Kinetic Energy Theorem Questions:

8. A student wearing frictionless roller skates on a horizontal surface is pushed by a friend with a constant force of 45 N. How far must the student be pushed, starting from rest, so that her final kinetic energy is 352 J?

$F = 45N$, $KE = W = 352J$, $d = x$, $\theta = 0$

$W = Fd\cos\theta$

$d = \frac{W}{F\cos\theta} = \frac{352J}{45N \cdot \cos 0} = \boxed{7.82m}$

9. A 2.1×10^3 kg car starts from rest at the top of a driveway that is sloped at an angle of 20.0° with the horizontal. An average friction force of 4.0×10^3 N impedes the car's motion so that the car's speed at the bottom of the driveway is 3.8 m/s. What was the length of the driveway?

IGNORE #9 TOO HARD

$\Sigma F = (2100\text{kg})(10)\sin 20 - 4000\text{N} = 3182\text{N}$ $\quad a = \frac{3182\text{N}}{2100} = 1.52\text{m/s}^2$

$(3.8)^2 = 0^2 + 2(1.52)d$ $\quad d = \boxed{4.8\text{m}}$

10. A 75 kg bobsled is pushed along a horizontal surface by two athletes. After the bobsled is pushed a distance of 4.5 m starting from rest, its speed is 6.0 m/s. Find the magnitude of the net force on the bobsled.

$v = 6\text{m/s}$ $\quad m = 75\text{kg}$ $\quad KE = W = x$

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(75\text{kg})(6\text{m/s})^2 = 1350\text{J}$

$W = KE = 1350\text{J}$ $\quad F = x$ $\quad \theta = 0$ $\quad d = 4.5\text{m}$

$W = Fd\cos\theta$

$F = \frac{W}{d\cos\theta} = \frac{1350\text{J}}{4.5\cdot\cos 0} = \boxed{300\text{N}}$

11. A 755 N diver drops from a board 10.0 m above the water's surface. Find the diver's speed 5.00 m above the water's surface. Then find the diver's speed just before striking the water.

$mg = 755\text{N}$ $\quad h = 10.0\text{m}$ $\quad PE = x$

$PE = mgh = (755\text{N})(10\text{m}) = 7550\text{J}$

$PE = KE$

$PE = \frac{1}{2}mv^2$

$v = \sqrt{\frac{2PE}{m}} = \sqrt{\frac{2(7550\text{J})}{75.5\text{kg}}} = \boxed{14.1\text{m/s}}$

$\frac{1}{2}PE = \frac{1}{2}KE$ AT 5m ⇨

$v = \sqrt{\frac{2PE}{m}} = \sqrt{\frac{2(3775\text{J})}{75.5\text{kg}}} = \boxed{10\text{m/s}}$

12. If the diver in problem 11 leaves the board with an initial upward speed of 2.00 m/s, find the diver's speed when striking the water.

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(75.5\text{kg})(2\text{m/s})^2 = 151\text{J}$

$ME = KE + PE = 151 + 7550 = 7701\text{J}$

$v = \sqrt{\frac{2(ME)}{m}} = \sqrt{\frac{2(7701\text{J})}{75.5\text{kg}}} = \boxed{14.3\text{m/s}}$

13. A pendulum bob is released from some initial height such that the speed of the bob at the bottom of the swing is 1.9 m/s. What is the initial height of the bob?

$v = 1.9\text{m/s}$ $\quad h = x$

$PE = mgh$ $\quad KE = \frac{1}{2}mv^2$

$PE = KE$

$mgh = \frac{1}{2}mv^2$ ⇨ $h = \frac{v^2}{2g} = \frac{(1.9\text{m/s})^2}{2(10\text{m/s}^2)} = \boxed{0.181\text{m}}$

Power Questions:

14. A 1.0×10^3 kg elevator carries a maximum load of 800.0 kg. A constant frictional force of 4.0×10^3 N retards the elevator's upward motion. What minimum power, in kilowatts, must the motor deliver to lift the fully loaded elevator at a constant speed of 3.00 m/s?

$\Sigma F = 1000\text{kg}(10\text{m/s}^2) + 800\text{kg}(10\text{m/s}^2) + 4000\text{N} = 22{,}000\text{N}$

$P = \frac{W}{t} = \frac{Fd}{t} = F\left(\frac{d}{t}\right) = Fv$

$P = (22{,}000\text{N})(3\text{m/s}) = \boxed{66{,}000\text{W}}$

15. A rain cloud contains 2.66×10^7 kg of water vapor. How long would it take for a 2.00 kW pump to raise the same amount of water to the cloud's altitude of 2.00 km?

$F = mg = (2.66 \times 10^7\text{kg})(10\text{m/s}^2) = 2.66 \times 10^8\text{N}$

$P = 2000\text{W}$ $\quad d = 2000\text{m}$ $\quad t = x$

$P = \frac{Fd}{t}$ ⇨ $t = \frac{Fd}{P} = \frac{(2.66 \times 10^8\text{N})(2000\text{m})}{2000\text{W}} = \boxed{2.66 \times 10^8\text{s}}$

16. A 1.50×10^3 kg car accelerates uniformly from rest to 10.0 m/s in 3.00 s.

a. What is the work done on the car in this time interval?

$m = 1500\text{kg}$ $\quad v = 10\text{m/s}$

$KE = \frac{1}{2}mv^2 = \frac{1}{2}(1500\text{kg})(10\text{m/s})^2 = \boxed{75000\text{J}}$

b. What is the power delivered by the engine in this time interval?

$W = 75000\text{J}$ $\quad P = x$ $\quad t = 3\text{s}$

$P = \frac{W}{t} = \frac{75000\text{J}}{3\text{s}} = \boxed{25000\text{W}}$